ATTENTION-DEFICIT HYPERACTIVITY DISORDER AND EXPOSURE TO NATURE IN COLLEGE STUDENTS

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LAURA THAL

Dr. Sonja Wilhelm Stanis, Thesis Supervisor

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The undersigned, appointed by the dean of the Graduate School, have examined the thesis entitled

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EXPOSURE TO NATURE IN COLLEGE STUDENTS

Presented by Laura Thal,

a candidate for the degree of master of Parks, Recreation and Tourism,

and hereby certify that, in their opinion, it is worthy of acceptance.

Assistant Professor Sonja A. Wilhelm Stanis

Associate Professor Mark Morgan

Assistant Professor Eileen Bjornstrom

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ABSTRACT

Attention-deficit hyperactivity disorder (ADHD) is one of the most prevalent behavioral disorders in the U.S. and has significant cognitive and behavioral symptoms (e.g., challenges in focus, memory, and sustained attention). Although ADHD is traditionally associated with childhood, symptoms can persist into young adulthood and cause profound academic difficulties with subsequent professional implications. A growing body of research explores the connection between nature exposure and cognitive functioning as an alternative to traditional, largely pharmaceutical treatment of ADHD. According to Kaplan's Attention Restoration Theory, because natural environments are inherently stimulating and therefore restorative, they are key to the recovery of cognitive mechanisms that enable sustained attention. As no major study to date has tested this theory in young adults diagnosed with ADHD specifically, this study explored the ability of natural environments to restore attentional capacity of college students with ADHD, as measured by cognitive performance, self-reported symptoms, and perceptions of restoration in one of two different environments. Participants took 20-minute walks in either a natural or urban area and completed these measures before and after the walk. Both the cognitive performance and perceived symptoms of the nature group improved following the walk, although only one of three measures of cognition showed significant improvement over the urban group. In addition, the nature group perceived their walk environment to be significantly more restorative than the urban group. These findings support previous research which suggests the importance of natural environments as sources of cognitive restoration for a population with existing attentional deficits.

CHAPTER I:

INTRODUCTION

Attention Deficit Hyperactivity Disorder

Attention deficit hyperactivity disorder (ADHD, sometimes referred to as ADD or childhood hyperkinesis) is one of the most commonly diagnosed behavioral disorders, affecting between 3% and 9% of school-aged children (Centers for Disease Control and Prevention [CDC], 2010a), an estimated 2-8% of U.S. college students (Weyandt & DuPaul, 2006) and 4.2% of working adults in the United States (Kessler et al., 2005). Symptoms of ADHD are typically defined as hyperactivity, impulsivity, and inattention that individually or collectively impair functioning in home, work, and/or school settings (American Psychiatric Association [APA], 2000). Consequently, school-aged children who suffer from ADHD may experience difficulty with classroom tasks, behavioral problems, decreased self-esteem, and challenging family and peer relationships (Doshi et al., 2012). There is no known cause of ADHD or any specific risk factors, but research shows that ADHD may be inherited genetically (National Institutes of Health [NIH], 2012).

There are three subtypes (predominantly inattentive, predominantly hyperactive-impulsive, and combined type) and each diagnosis is determined by the presence of corresponding symptoms (e.g., an individual meeting six or more of the criteria for inattention symptoms for the past six months is diagnosed with ADHD, predominantly inattentive type; APA, 2000). The combined type, in which both inattention and hyperactivity/impulsivity symptoms are present, is the most common subtype and accounts for 50-75% of individuals with ADHD, followed by 20-30% predominantly inattentive and less than 15% predominantly hyperactive-impulsive (Searight, Gafford, & Evans, 2009).

Often thought to be a disorder associated exclusively with childhood, recent studies have found that difficulties posed by this disorder can persist well into adolescence and adulthood. Specifically, while the symptoms of hyperactivity and impulsivity may decline, the remaining symptom of inattention may continue into adulthood (Wilens et al., 2004; Wilens et al., 2009). Moreover, recent studies have found many troubling correlations between adults with ADHD and an increased prevalence of comorbid (i.e., co-occurring) mental disorders such as depression and anxiety (Murphy & Barkley, 1996), decreased work productivity (Kessler et al., 2005), and frequent job turnover (Murphy & Barkley, 1996). Interestingly, one study further analyzed comorbidity rates by gender and disorder type; specifically, men experienced a much higher rate of comorbid conduct disorders and alcohol abuse, while women experienced significantly higher rates of comorbid mood and anxiety disorders (Wilens et al., 2009).

Besides the prevalence of comorbid disorders in ADHD populations, treating this disorder can have both tangible and intangible costs for those affected by it. For example, one study found that only 31% of students with ADHD (regardless of medication use) pursue a postsecondary education (Wagner, Newman, Cameto, Garza, & Levine, 2005), and the graduation rate for this group is 28%, about half of the rate for their peers without disabilities (Connor, 2012). Besides this innate challenge for young adults transitioning to college life, ADHD can have tangible costs to both children and adults; one study, which employed a systematic review of primary studies spanning two decades, found that per-

person annual costs associated with ADHD resulted from healthcare costs ($621-$2,720 for children/adolescents, $137-$4,100 for adults) and productivity/income losses ($209-$6,699 for adults ages 18-64), among others (Doshi et al., 2012). Evidently, significant challenges to educational potential, along with monetary costs, exist for those suffering from ADHD.

Treatment of ADHD

Current treatments for ADHD include support groups, behavioral intervention therapy, diet modification, and medications of both stimulant (e.g., methylphenidate, amphetamines) and non-stimulant (e.g., antidepressants) varieties (Wilens, Faraone, & Biederman, 2004). Especially in children, medication is a widely used treatment, with approximately 66.3% of children ages 4-17 being treated with medication (CDC, 2010b). The dominant medication regimen for children and adolescents is stimulant drugs (National Institute of Mental Health [NIMH], 2008), with a non-response rate (i.e., percent of children showing no change after medication use) of 15-30% (Swanson, 2003) and possible side effects including decreased appetite, insomnia, and development of muscle “tics” (NIMH, 2008).

Although the benefits of treating ADHD with medication to reduce symptoms in children have been recognized (NIMH, 2008), the effectiveness of treating adult ADHD with stimulant medication is less established (Wilens et al., 2004); only a few meta-analyses have been conducted on the subject, and the efficacy level, although positive, is not consistent among researchers. Specifically, two meta-analyses were conducted to examine the efficacy of methylphenidate (Faraone, Spencer, Aleardi, Pagano, &

Biederman, 2004; Koesters, Becker, Kilian, Fegert, & Weinmann, 2009), and although they both concluded that the medication had a significant effect on symptoms of adult ADHD compared to placebo, Koesters et al. (2009) found an effect size less than half of that found by Faraone et al. (2004). A more recent meta-analysis (Castells et al., 2011) found a moderate effect for the drug in adults, a figure between that of the two previous studies, and also took into account immediate-release vs. extended-release stimulants (i.e., medication effect lasting 3-6 hours vs. 8-12 hours, respectively). Evidently, immediate-release medication is more efficacious in adults for ADHD symptoms (Castells et al. 2011), although this requires multiple doses per day and a higher chance of missing a dose (Swanson, 2003). Clearly, medication is providing some relief for symptoms, although drugs like methylphenidate constitute only short-term rather than long-term relief.

Stimulant Abuse in College

Although stimulant medication such as methylphenidate may provide some relief from ADHD symptoms, it is not a perfect solution. University students may or may not be using medication to reduce symptoms of ADHD, which is of particular concern as they are adapting to living independently, forming social support networks, and cultivating academic habits that could affect students' success later in life (Connor, 2012). As a Schedule II stimulant drug, by definition it has substantial potential for abuse, and is classified in the same category as methamphetamine and cocaine under the U.S. Controlled Substance Act (U.S. Food and Drug Administration [FDA], 2009). According to the U.S. Department of Justice's Drug Enforcement Administration, "of particular concern is that ADHD literature prepared for public consumption does not address the potential or actual abuse of methylphenidate. Instead, methylphenidate is routinely portrayed as a benign, mild substance that is not associated with abuse or serious side effects. In reality, however, the scientific literature indicates that methylphenidate shares the same abuse potential as other Schedule II stimulants" (Drug Enforcement Administration [DEA], 1995).

Considering its potential for abuse, along with rampant diversion, or illegal redistribution, of stimulant medication among college students (Aikins, 2011), alternative treatment for this age group is imperative. While children and adolescents seeking treatment for ADHD may feel stigmatized (Wiener et al., 2012; Moses, 2009), quite the opposite trend seems to emerge when these students reach college. Individuals who are prescribed ADHD medication in college may experience a great deal of pressure from their peers to divert this controlled substance to friends and classmates who view the drug as an academic aid for all (Aikins, 2011). In fact, as many as 34% of college students have reported using ADHD medication illegally, with even higher rates among male students (39%), juniors (49%), seniors (55%), and Greek letter organization members (48%; DeSantis et al., 2008). Surprisingly, only 4% of students in this study reported having a prescription for their ADHD medication (DeSantis et al., 2008). Perhaps the cultural expectation to "share" prescription stimulants in college, easy access to the drug from other students, and the strict DEA regulations on prescribing stimulants (usually limited to a 30 days' supply with no refills) contribute to the small amount of students seeking out legal access to ADHD medication. Clearly, this age group is in need of a solution for alleviating ADHD symptoms that does not rely solely on highly controlled medication.

Alternative Treatments

The persistence of inattention symptoms into adulthood, the substantial population affected, the presence of many comorbid disorders within this population, and a number of issues with current pharmaceutical treatment, including its limited efficacy and high potential for abuse, suggest further exploration of alternative treatment of ADHD symptoms to replace or supplement medication use. For children and adults alike, additional treatment options could potentially improve attitude and temperament, productivity, self-esteem, and overall professional or academic performance.

The effectiveness of many alternative treatments for ADHD has been evaluated over the past few decades by several researchers conducting meta-analyses (e.g., Rojas & Chan, 2005; Searight, Robertson, Smith, Perkins, & Searight, 2012). Some of the more controversial treatments include sugar reduction diets, homeopathy, biofeedback, and computer-based training, all of which have been criticized for various reasons. First, the belief that excessive sugar intake is an underlying cause of ADHD symptoms was debunked by a systematic review by Wolraich and colleagues, which concluded that sugar intake had no effect on children's behavior or cognitive performance (Wolraich, Wilson, & White, 1995). Similarly, studies on homeopathic remedies for ADHD symptoms are both small in number and have been riddled with major oversights in methodology, such as including methylphenidate as a part of the intervention, and thus have led to largely inconclusive findings (Rojas & Chan, 2005). Biofeedback therapy, on the other hand, has shown potential in terms of efficacy (Arns, de Ridder, Strehl, Breteler, & Coenen, 2009), but suffers from major methodological issues and extremely high cost of treatment (Rojas & Chan, 2005). Lastly, computer-based cognitive training regimens for children with ADHD may provide temporary improvements in executive functioning, but lack evidence of long-term relief. Although several studies using commercial programs such as *Cogmed* saw significant improvements in working memory (i.e., one component of executive functioning; Holmes et al. 2010; Klingberg, Forssberg, & Westerberg, 2002; Klingberg et al., 2005), one of the studies suggested that these results were diminished by the time of the six-month follow-up (Klingberg et al., 2005). Overall, this body of literature is lacking peer-reviewed, methodologically sound studies, although many have recommended the use of combining these alternative treatments with medication for improved results.

One other avenue for alternative treatment can be found in the growing body of research exploring the connection between nature exposure and improved cognitive functioning (e.g., Tennessen & Cimprich, 1995; Wells, 2000; Berman, Jonides, & Kaplan, 2008). A subset of this research field has focused on populations with ADHD in particular to determine the prevalence of symptoms before and after nature exposure (e.g., Faber Taylor & Kuo, 2009; van der Berg & van der Berg, 2010). “Green therapy” is currently among those alternative treatments that show a great deal of potential (Faber Taylor, Kuo, & Sullivan, 2001), especially considering the low cost and fairly widespread availability of green space. Some evidence suggests that exposure to nature may even be comparable to current drugs used to treat ADHD (Faber Taylor & Kuo, 2009). Even so, advocates of this treatment require additional peer-reviewed research in order to validate its potential as an effective supplementary treatment to medication use. If evidence is built to support the effectiveness of nature's role in attention restoration, then additional mechanisms and treatments for individuals struggling with ADHD may become available to cope with their symptoms, improve cognitive performance, and manage stress caused by sustained attention.

<u>Need For Study</u>

Although the restorative effects of nature exposure have been examined in a number of studies, few studies have been conducted specifically with ADHD populations. Further, no studies to date have involved college students diagnosed with ADHD despite the prevalence of ADHD in this population and potential impacts on academic success (Frazier, Youngstrom, Glutting, & Watkins, 2007). Most previous research has either focused exclusively on children with ADHD (e.g., Faber Taylor & Kuo, 2009) or the general university student population (not focused specifically on ADHD; e.g., Berman et al., 2008). As such, findings from this study may provide further insight into the relationship between exposure to nature and ADHD symptoms, particularly in college students experiencing cognitive challenges innate to their diagnosis. This is particularly important as current available treatments are not effective for all individuals dealing with ADHD, may offer only limited relief from symptoms, and medications also involve some risks and possible side effects (Barkley, 2006; MTA Cooperative Group, 2004; Faber Taylor & Kuo, 2009).

Study Purpose and Research Questions

The purpose of this study was to explore the relationship between walking in natural environments (as compared to urban environments) and cognitive restoration of university students professionally diagnosed with ADHD. Specifically, restoration was examined through cognitive performance, self-reported prevalence of ADHD symptoms, and the perceived restorativeness of each environment. Accordingly, the study assessed three research questions:

Research Question 1: To what degree does cognitive performance change in university students with ADHD following exposure to a natural verses urban environment?

> As previous research that has shown that walking in general can improve cognitive performance (Voss et al., 2010) and there is a potential learning effect of completing the cognitive tasks more than once (e.g., Berto, 2005), it is hypothesized that there will be an improvement in both the urban and nature groups' performance on cognitive tasks, but that improvement will be greater for the nature group.

Research Question 2: To what degree does the prevalence of self-reported ADHD symptoms change in university students following exposure to a natural verses urban environment?

> As previous research indicates that exercise in general can reduce ADHD symptoms (Halperin & Healey, 2011), it is hypothesized that there will be a

decrease in the prevalence of reported symptoms in both groups, but decrease will be greater in the nature group.

Research Question 3: What is the perceived restorativeness of natural versus urban environments?

Some degree of perceived restorativeness is expected in both groups, but as previous research indicates natural environments to have more of the qualities of a restorative environment than urban (Kaplan, 1995), it is hypothesized that the perceived restorativeness of the environment will be greater for the nature group.

Definitions

Attention-Deficit Hyperactivity Disorder: neurobehavioral disorder with core symptoms of inattention, hyperactivity, and impulsivity (Searight, Gafford, & Evans, 2009).

Attention Restoration Theory: Posits that 1) two mechanisms of attention exist: one deliberate and effortful (*directed*) and one effortless (*involuntary*); 2) directed attention is subject to fatigue and restoration; and 3) natural environments satisfy the criteria for being restorative and therefore possess the potential to restore directed attention that has been fatigued (Faber Taylor & Kuo, 2009).

Comorbidity (also called comorbid disorder): the presence of a secondary disorder in addition to a primary disorder (e.g., high rate of comorbid depression in adult ADHD populations; Murphy & Barkley, 1996).

Digit Span Backwards (DSB): a standardized measure of concentration widely used to diagnose ADHD, in which a sequence of numbers is read aloud to participants (e.g., 3-1-4) and repeated in reverse order by participants (e.g., 4-1-3; Faber Taylor & Kuo, 2009).

Directed Attention (formerly called Voluntary Attention): a conscious form of attention that involves the inhibition of outside stimuli in order to attend to a specific stimulus (e.g., reading a textbook, actively listening to an academic lecture; Kaplan, 1995).

Directed Attention Fatigue: subsequent exhaustion following sustained mental effort (e.g., airline pilots after long flights; Kaplan, 1995).

Diversion (of prescription drugs): "the unlawful channeling of regulated pharmaceuticals from legal sources to the illicit marketplace" (Inciardi, Surratt, Kurtz, & Burke, 2006, p. 255; i.e., the illegal redistribution of prescription drugs to individuals without a prescription).

Extended-Release Stimulant Medication: long-acting medication with effect duration of 8-12 hours and taken once daily (e.g., Concerta; Searight et al., 2009).

Immediate-Release Stimulant Medication: short-acting medication with effect duration of 3-6 hours and taken 2-3 times (e.g., Ritalin, Methylin; Searight et al, 2009).

Involuntary Attention: an unconscious form of attention that requires no effort and is caused by inherently exciting or interesting stimuli (Kaplan & Berman, 2010).

Methylphenidate: a Schedule II stimulant drug prescribed predominantly for the treatment of ADHD symptoms (DEA, 1995).

Restorative Environment: an environment that possesses the qualities of *being away* ("being distinct, either physically or conceptually, from the everyday environment"), *fascination* ("containing patterns that hold one's attention effortlessly”), *extent* (“having scope and coherence that allow one to remain engaged”), and *compatibility* (“fitting with and supporting what one wants or is inclined to do”; Kaplan, 2001).

Schedule II Drug: any drug or other substance with a) a high potential for abuse, b) a currently accepted medical use with or without high restrictions, and c) potential for severe psychological or physical dependence caused by abuse (as defined in Section 812 of the U.S. Controlled Substance Act; FDA, 2009).

Stimulant Medication: drugs which have a stimulant effect on central nervous system (i.e., causes increased production in the brain of the neurotransmitter dopamine, which regulates pleasure, movement, and attention; NIH, 2009).

Stress Recovery (also referred to as Restoration): “*positive* changes in psychological [i.e., emotional] states, in levels of activity in physiological systems, and often in behaviors or functioning, including cognitive functioning or performance” following a stressful situation (Ulrich, 1991, p. 202).

Stress Recovery Theory: theory which posits that exposure to natural environments stimulate positive emotions, therefore suppressing negative emotions, and allowing recovery from stressful events to take place (Ulrich, 1983).

Stroop Color Word Test: a cognitive test designed to measure cognitive flexibility and inhibition of outside stimuli, in which color names are written in different colors and participants need to say the color of the text rather than the name written (Schiehser & Bondi, 2010).

CHAPTER II:

LITERATURE REVIEW

The field exploring the importance of exposure to nature for physical, social, and cognitive development has experienced extensive growth in the past few decades (Velarde, Fry, & Tveit, 2007) and has received a great deal of attention by researchers using varied methods and approaches (e.g., Berman et al., 2008; Berto, 2005; Mayer, McPherson Frantz, Bruehlman-Senecal, & Dolliver, 2009). A limited subset of studies within the realm of nature exposure has focused specifically on the interaction between individuals diagnosed with ADHD and natural environments (e.g., Kuo & Faber Taylor, 2004; Faber Taylor & Kuo, 2009). By the very nature of this disorder, directed attention in these individuals is often more challenging or impaired than in the larger population, so interest in this population is appropriately founded.

Physical and Social Benefits of Nature Exposure

In terms of physical benefits for the general population, many researchers have found various manifestations of improved health following exposure to nature. Ulrich (1984) conducted a study of recovering gallbladder surgery patients who had either a view of trees or a brick wall from their recovery room, and found that the tree-view group had shorter hospital stays, required lower doses of painkillers, and experienced slightly less postsurgical complications. Another study, focusing on university students, found that participants who had direct exposure to nature saw greater stress reduction as indicated by subsequent lower blood pressure (Hartig, Evans, Jamner, Davis, & Gärling, 2003). These studies lend themselves to the Ulrich's larger theory of Stress Recovery (Bratman, Hamilton, & Daily, 2012), whereby exposure to natural environments stimulate positive emotions, therefore suppressing negative emotions, and allowing recovery from stressful events to take place (Ulrich, 1983). For example, in a study conducted at a state prison, a decidedly stressful environment, Moore (1980) observed that inmates with outside views of forest or farmland made less medical visits than those with views of the walled prison yard.

Exposure to nature has also been shown to provide opportunities for social development, as illustrated by various studies. Coley, Sullivan, & Kuo (1997), for example, found that the presence of natural elements in public housing developments was associated with more use of outdoor spaces by residents, and therefore created increased opportunities for social interaction, as well as supervision of children. Another study of urban public housing areas focused on two critical aspects of children's social development, play and access to adults, and found that both were far more prevalent in areas with more vegetation (Faber Taylor, Wiley, Kuo, & Sullivan1998). Natural elements have the potential to facilitate social interaction, even in low-income areas that suffer from social maladies like increased crime rate.

Even so, the area of cognitive benefits of nature exposure is of particular interest for individuals with ADHD, and has a research base that straddles various disciplines such as environmental psychology, public health, and social work.

Cognitive Benefits of Nature Exposure

Attention Restoration Theory

The concept that has become the cornerstone of this field that explores the connection between exposure to nature and cognitive performance is Kaplan's Attention Restoration Theory, or ART (S. Kaplan, 1995, 2001). This environmental psychology theory suggests that natural environments are inherently *restorative*, and that these restorative environments allow internal *directed attention* mechanisms to recover from stress and subsequently perform better. In order to fully understand ART and its theoretical context, a few of the aforementioned concepts require further explanation.

ART is an extension of James's (1892) distinction between two types of attention that are used in cognitive functioning: *voluntary* vs. *involuntary* attention. Involuntary attention is attention that requires no effort and is caused by inherently exciting or interesting stimuli (Kaplan & Berman, 2010). In contrast, voluntary attention, as the name suggests, is that which only occurs after exerting effort and consciously focusing on stimuli. One experiences voluntary attention "whenever we resist the attractions of more potent stimuli and keep our mind occupied with some object that is naturally unimpressive" (James, 1892, p. 224). Now called *directed attention* (S. Kaplan, 1995), it is described as requiring effort through forcing oneself to pay attention to something that is not particularly interesting (Kaplan & Berman, 2010). Specifically, directed attention is "employed when something did not of itself attract attention, but when it was important to attend nonetheless" (S. Kaplan, 1995, p. 169).

Because directed attention requires effort, it is susceptible to fatigue (S. Kaplan, 1995). Although James did not acknowledge the possibility of fatiguing this mechanism for voluntary (i.e., directed) attention, Frederick Law Olmsted, famous for leading the urban parks movement and one of the original designers of Central Park in New York City, did in fact make this connection (S. Kaplan, 1995). In 1865, even before James' work with attention was published, Olmsted recognized that the capacity to focus may be fatigued and even went on to vouch for the important role of nature in this process of recovery (as cited in S. Kaplan, 1995, p. 170).

ART proposes that *directed attention* might be more likely to recover if it is allowed to rest, or be restored (Kaplan & Berman, 2010). Specifically, an environment can be *restorative* through the attraction of involuntary attention and the limited need for directed attention (Berto et al., 2010). This theory suggests natural environments (e.g., parks, gardens, trails) are restorative setting in that they are able to capture involuntary attention and minimize directed attention requirements, while urban environments require directed attention to deal with stimulation making the setting less restorative (Berto et al., 2010; Kaplan & Berman, 2010).

Kaplan (1995) outlines the components of *restorative* environments: *being away, fascination, extent,* and *compatibility. Being away* refers not only to traveling great distances for breathtaking natural scenery, but also simply accessing natural environments in the nearby area that offer a change of scenery in general. *Fascination* occurs when any stimulus- a cloud, a sunset, leaves rustling in the wind- passively and effortlessly captures attention from onlookers. *Extent* does not require huge expanses of land, as the name might convey. It simply refers to a feeling of connectedness, either spatially (using miniaturization in smaller parks to create the sensation of vastness) or temporally (in the case of historical monuments). Finally, *compatibility*, is achieved when people feel "at one" with their environment, whether it is through hunting, hiking, or observing wildlife. Any of these activities, and many more, are said to create a sense of familiarity and ease for visitors, and therefore create an opportunity to escape the demands of voluntarily directing attention, hence creating a restorative environment.

Nature Intervention Studies

Numerous studies have tested the theory of Attention Restoration with a range of participant ages, measurement tools, and sample sizes have examined this hypothesis that interaction with natural environments can restore depleted directed attention, and subsequently help one perform better on tasks that depend on directed attention (e.g., Berman et al., 2008; Berto 2005; Berto et al., 2008; Herzog & Strevey, 2008; Kuo & Sullivan, 2001; Mayer et al., 2009; Laumann et al., 2003; Tennessen & Cimprich, 1995; See Table 1). For example, Berman et al. (2008) conducted a controlled intervention study in which participants took a 50-minute walk in either a park or downtown environment. Using a backwards digit-span task to measure directed attention following the intervention, researchers found that walking in natural as opposed to urban environments was more restorative. Mayer et al. (2009) also utilized a controlled intervention experimental model and found that direct exposure to nature was associated with not only improved attention capacity, but also increased connectedness to nature, positive emotions, and improved ability of reflection on life problems. A recent study by Aspinall, Mavros, Coyne, and Roe (2013) took a novel approach by using mobile electroencephalography (EEG) technology to measure brain activity, including directed attention (i.e., "engagement" in this study), throughout a contiguous walk with three distinct environment zones (urban shopping street, green space, busy commercial district). This study found that participants experienced reductions in engagement (i.e., directed attention) and frustration while transitioning from the urban shopping street to the green space, and conversely saw higher levels of engagement while moving out of the green space into the busy commercial district. Results of this study are in line with current restoration theory and encompass both Kaplan's and Ulrich's work with attention and emotional restoration, respectively.

Additional studies have found that exposure to nature, even indirect exposure through simply viewing natural environments, has other distinct benefits. Rachel Kaplan (2001) found that views of nature from the home were positively correlated with effective functioning and feelings of being at peace, and negatively correlated with distraction. Herzog & Strevey (2008) revisited this concept, focusing not only on views from the home but general self-report measures, and found that of these well-being factors, contact with nature was the strongest predictor of effective functioning in particular. Effective functioning in this case was measured by the degree to which respondents reported being "attentive", "focused," "effective," etc. (Herzog, 2008).

Even viewing pictures of natural environments has been shown to provide restorative opportunities for attention. For example, Berto (2005) administered a sustained attention test before and after participants viewed natural environments, urban scenes, or geometric patterns, and found that only the group that viewed the natural environments saw improved attention capacity, as measured by increased number of correct responses, decreased reaction time, and improved target detection.

Taken together, there is widespread support for the restorative effect of nature exposure, whether it is a result of direct interaction (i.e. walking in natural environments) or indirect interaction (i.e. viewing nature from windows or viewing pictures of natural settings). However, limited research has examined the impacts of nature exposure on individuals with ADHD, despite numerous studies that recognize the importance of this research for ADHD populations that could particularly benefit from restored directed attention (e.g., Perkins et al., 2011).

Nature and ADHD Population

References to symptoms of what we now know as ADHD have appeared in literature as far back as 1865, with Heinrich Hoffman's poetry featuring "Fidgety Phil." However, the field of ADHD research and diagnosis did not gain stamina in the scientific or popular world until the 1970s (Barkley, 2006). More recently, a small but growing cohort of researchers has focused on the benefits of nature exposure specifically for ADHD populations. Directed attention fatigue is more likely to be prevalent in this group due to the symptoms of ADHD, so specific application of ART with this population could be of particular use in providing additional evidence for the theory, as well as developing alternative treatments for ADHD.

To test whether ART held true for children with ADHD, Kuo and Faber Taylor (2004) conducted a nationwide survey with items taken from the official ADHD diagnostic guidelines (American Psychiatric Association, 2000). Expanding on an earlier study that surveyed only 96 parents of children ages 7-12 (Faber Taylor, Kuo, & Sullivan, 2001), this study included 452 children ages 5-18. Researchers found that spending time in more "green" activity areas, as opposed to indoor or built outdoor settings, after school and on weekends did in fact help to reduce the severity of symptoms of ADHD, as measured by parental responses. These researchers later expanded this study by conducting controlled trials to supplement their findings from the earlier survey. After exposing 17 children to each of three environments (a city park, downtown area, and residential area), concentration was shown to improve significantly after park exposure and not after the other two settings. This research team even posits that the effects of "a dose of green" are comparable to those of extended-release methylphenidate, a psycho-stimulant drug used for treating ADHD (Faber Taylor & Kuo, 2009). Furthermore, a study of children with ADHD ages 9-17 in the Netherlands found similar results; although the sample size was limited, with two groups of six children, researchers saw improved concentration task scores following a visit to a wooded area rather than a nearby town (van der Berg & van der Berg, 2010).

Overall, despite the growing interest in the restorative effects of nature for individuals with ADHD, the body of literature is still lacking. Only a few controlled intervention studies have been conducted with ADHD youth (e.g., Faber Taylor & Kuo, 2009; van der Berg & van der Berg, 2010), and most of these studies have extremely small sample sizes, therefore additional research is needed that utilizes larger sample sizes as well as a broader age range of ADHD populations. Studying college students with ADHD is the next logical step in expanding this research to the general ADHD population.

Table 1. Studies Using Nature Interventions

Study	Sample	Nature Exposure	Major Findings
Studies of Adults (non-ADHD population)			
Kaplan (1993)	Office workers	View from office window	Employees with views of nature from their workspace reported fewer physical ailments, higher job satisfaction, less frustration, and higher enthusiasm for their work
Cimprich & Ronis (2003)	Cancer patients (adult females)	120 mins of nature activities per week (home-based, recorded in journal)	Patients who were assigned to walk in nature following surgery had a higher recovery of directed attention abilities
Ulrich (1984)	Surgical patients	Views from hospital recovery room (trees vs. brick wall)	Patients with views of trees had shorter hospital stays, required lower doses of painkillers, and experienced slightly less postsurgical complications
Studies of College Students (non-ADHD population)			
Berman et al. (2008): Exp. 1	College students	50-55 min walk in both arboretum and urban area (2.8 miles each) one week apart	Directed attention improved significantly after walking in arboretum and not after walking downtown
Berman et al. (2008): Exp. 2	College students	Pictures of nature vs. urban scene one week apart	Executive functioning (i.e., directed attention) was improved only after viewing pictures of nature and not urban scenes
Berto (2005)	College students	Viewing pictures of nature, urban, or geometric patterns after initial mental fatigue	Only the group who viewed pictures of nature regained attention capacity (i.e., improved scores on cognitive test); no change in geometric pattern group
Felsten (2009)	College students	Views on murals of dramatic nature scenes, mundane natural areas with built structures present, and completely lacking nature	Students rated views of dramatic nature murals as the most restorative, followed by window views of mundane nature, and no view of nature as least restorative
Studies of Children with ADHD			
Kuo & Faber Taylor (2004)	Children w/ ADHD (ages 5-18)	After-school and weekend activities (green outdoor, built outdoor, indoor spaces)	Green outdoor activities (as opposed to indoor or built outdoor activities) resulted in reduced symptoms and had more positive aftereffects on symptoms than did activities conducted in other settings
Faber Taylor & Kuo (2009)	Children w/ ADHD (ages 7-12)	Three 20-min walks in each of 3 settings: urban park, downtown area, residential area	Cognitive functioning improved only after walking in the natural setting
van der Berg & van der Berg (2010)	Children w/ ADHD (ages 9-17)	One hour in either a wooded area or town (while staying at one of two different care farms)	Groups from both care farms performed better on a concentration test in the wooded setting rather than the town setting

CHAPTER III:

RESEARCH METHODS

This study examined the effects of exposure to natural settings on young adults with ADHD. The intervention consisted of a set of field trials with pre- and post-intervention cognitive testing and self-administered questionnaires. The research design followed a similar overall procedure to those used in previous studies (i.e., Berman et al., 2008; Faber Taylor & Kuo, 2009; Perkins et al., 2011), but applied specifically to young adults with ADHD. The following sections describe the study location and population, research design, data collection, measures, and data analysis.

Study Location and Participants

This study took place in Columbia, Missouri, a city of nearly 115,000 residents that houses two colleges and one university (i.e., Columbia College, Stephens College, and the University of Missouri). Participants of this study were University of Missouri students who had, at some point in their lives, been professionally diagnosed with ADHD. Medication use was not a determining factor of recruitment, although it was asked on the questionnaire. To recruit these participants, a weekly announcement was posted and distributed to the listserv of current students using the campus-wide MU Info mass email system. A flyer was also created and posted in various campus buildings. To assist in recruitment, students were offered a $20 gift card for the campus bookstore as an incentive for participation. A total of 40 students participated in the study.

Research Design

The intervention consisted of a set of field trials in which participants were randomly assigned to take a 20-minute walk in either a natural or urban setting. Following and preceding the walk, participants took a set of cognitive performance measures used to detect directed attention ability and completed a set of self-administered questionnaires to assess self-reported prevalence of symptoms and perceived restorativeness of the environment. The research design included three phases:

Phase 1: In the first phase of the study, which lasted approximately twenty minutes, two computer-based cognitive tests were administered on-site to each participant, as well as a self-administered paper questionnaire. The pre-walk questionnaire asked participants to report current ADHD symptoms, demographic information, nature experience (e.g., enjoyment of nature), and ADHD history (e.g., age of diagnosis, medication use; see Appendix A).

Phase 2*:* The second phase of the study was the twenty-minute walk. Walks took place on either a wooded state park trail (i.e., nature) or a heavily urbanized street sidewalk (i.e., urban). Rock Bridge Memorial State Park served as the nature site, while Business Loop 70 served as the urban site. Participants walked individually and were not directly monitored during the intervention, but were given a small timer set to beep after ten minutes to signal the turnaround point. Timing ensured that each walk would last twenty minutes without having to regulate for varying paces of individuals. In order to be mindful of their surroundings, participants were instructed to leave phones and electronic devices in their cars or at the study site, which precluded their use for the duration of the walk.

Phase 3: The third phase of the study occurred immediately after the walk. A second round of cognitive tests and a post-walk questionnaire were administered in the same location as the first, also lasting about twenty minutes. This follow-up questionnaire asked about current ADHD symptoms, perceptions of the walk environment (e.g., noise level, safety), and the perceived restorativeness of each site (see Appendix B).

Data Collection

Data collection occurred over a four week period beginning in mid-October 2013. This timing allowed for recruitment when students were available on campus, yet was before winter months in which the climate and weather conditions could impact the study findings (Perkins et al., 2011). Of the 40 total participants, 20 of them took a walk in the natural environment and 20 walked in the urban environment. Participants were assigned randomly into one of the two groups by alternating the nature-urban designation as each student signed up for the study. To ensure an even distribution of groups across the study period, data collection for each group was staggered by day (i.e., even-numbered calendar days were nature; odd-numbered urban). Participants were then allowed to choose from 3-4 possible one-hour timeslots on their assigned date based on their individual availability. The entire data collection process was conducted on-site and lasted about one hour per individual, including pre- and post-intervention measures (i.e., cognitive tests and questionnaires), as well as the walk itself.

Measures

Cognitive Tests

To measure the cognitive performance of participants (Research Question 1), two tests commonly used in diagnosing ADHD were administered, following Faber Taylor and Kuo (2009). The first was a computer-based version of the backwards digit-span task, or Digit Span Backwards (DSB; Inquisit, 2013). In this test, a sequence of numbers appeared on the screen one-at-a-time and participants were asked to enter the sequence in reverse order. If two consecutive sequences were entered correctly, then the number of digits would increase (beginning with 3 digits and ascending as high as 10). The DSB is widely used as a standardized measure of concentration because it is able to detect deficits in directed attention specifically; moving items in and out of one's attentional focus requires directed attention abilities, or executive functioning (Berman et al., 2008; Hale, Hoeppner, & Fiorello, 2002).

The second cognitive test was the Stroop Color-Word Test (SCWT) in which the names of colors appeared on the screen in one of four colors and participants were instructed to identify the color of the text rather than the text itself. For instance, if the word RED appeared on the screen in blue, the correct response would be "blue" (as measured by tapping one of four designated keys on the keyboard). By forcing participants to resist the automatic response of reading aloud the text, the SCWT is designed to measure selective attention and one's ability to resist interference from outside stimuli (parinc.com, 2012), one key aspect of directed attention (S. Kaplan, 1995). Although the SCWT includes both congruent (word and color match), incongruent (word and color differ) tasks, because only the incongruent trials require response inhibition (Schiehser & Bondi, 2010; Lansbergen, 2008), the current study's analysis focused on just the incongruent trials, both in terms of latency (i.e., reaction time) and the number of correct responses. This test is especially fitting for this study's sample because the ability to resist outside interference, or "interference control," is consistently compromised for those with ADHD (Lansbergen, Kenemans, & van Engeland, 2007).

Questionnaire

The questionnaires asked participants' perceptions about their current symptoms before and after the walk (Research Question 2) and their perceptions of the restorativeness of the environment they walked in (Research Question 3). Additionally, the questionnaires asked about each participant's specific diagnosis (e.g., age diagnosed, subtype), medication use, experience during the walk (e.g., noise level, traffic, safety), and demographic information.

Demographic and nature experience information was recorded before the walk and included questions regarding general demographic information (i.e., age, year in school, gender, ethnicity, race) as well as participants' use frequency and enjoyment of nature. For example, enjoyment of nature was measured by asking "To what degree do you enjoy spending time outdoors in natural areas (e.g., parks, forests, etc.)?" on a 5-point scale from 1=Strongly dislike to 5=Strongly enjoy.

ADHD Information was collected before the walk and included items about participants' ADHD medication use, age of diagnosis, ADHD subtype (i.e., (predominantly inattentive, predominantly hyperactive-impulsive, and combined type), and family history of ADHD (e.g., "Do you currently take medication to treat your ADHD symptoms?").

Perceptions of environment were measured after the walk using questions related to the intervention site itself. Specifically, these questions gauged the participants' perceptions of safety, noise level, car traffic (urban only), encounters with other people (nature only), and their personal familiarity with the area (e.g. "How safe would you rate this environment?" measured on a 5-point scale from 1=Very dangerous to 5=Very safe).

Current ADHD symptoms were measured before and after the walk. The questions were based on the Diagnostic and Statistical Manual of Mental Health Disorders (DSM-IV; APA, 2000) criteria used for diagnosing ADHD. Although the DSM-IV diagnosis combines hyperactivity and impulsivity into one subtype (i.e., predominantly hyperactive-impulsive type), the measurement is broken down by each of the three symptoms (i.e., inattention, hyperactivity, and impulsivity). Therefore, participants responded to two questions pertaining to each of the three main symptoms for a total of six items. The question asked the individual to report the degree to which they perceive themselves as experiencing each of the symptoms on a 5-point scale ranging from 1=Not at all to 5=Completely. An example item measuring inattention was "I feel easily distracted by things going on around me."

Perceived restorativeness of each environment was measured post-walk using items from the Perceived Restorativeness Scale (PRS; Hartig et al, 1997), which focuses on the four components of restorative environments outlined by S. Kaplan (1995): *being away*, *extent*, *fascination*, and *compatibility*. Specifically, participants were asked to evaluate 26 items regarding the extent to which the environment they recently walked in fulfills each of the criteria measured on a 5-point scale ranging from 1=Strongly Disagree to 5=Strongly Agree. For example, a question from the PRS measuring *being away* was "This setting allows me to get away from everyday thoughts and concerns." The PRS's validity was substantiated by one study that found a high degree of congruency between high PRS scores and improved physiological markers of stress recovery (e.g., lower cardiovascular blood volume pulse) after viewing images of natural scenes (Chang, Hammitt, Chen, Machnik, & Su, 2008).

Data Analysis

All analyses were conducted using SPSS 21 software. To check for any systematic differences between participants in each group, responses to survey items capturing personal information (i.e., demographic information, nature experience, ADHD history) and perceptions of their walk environment were compared across groups using chi-square and independent samples t-tests. Based on these comparisons, groups did not differ significantly by demographics, nature experience, or ADHD history. However, several significant differences emerged regarding perceptions of their walk environment, specifically perceived safety, familiarity, and noise level (see Table 4).

A perceived ADHD symptom scale was created by combining the six symptom items and a perceived environment restorativeness scale was created using 26 restorative items. Cronbach's alpha was used to examine the internal reliability of each scale, with a value larger than 0.70 considered acceptable (Cortina, 1993).

To assess changes in cognitive abilities (i.e., maximum correct digits in the DSB; latency and percent correct of incongruent trials in the SCWT), perceived ADHD symptoms scale, and perceived restorativeness of the environments scale, both within- and between-group comparisons were conducted. To examine changes in cognitive performance and the reported symptoms scale within each group, paired samples t-tests were used to compare pre- and post-walk scores. Given that perceived restorativeness was only assessed post-walk, within-group comparisons were not examined.

To assess if any observed changes differed between groups, a difference score was calculated for the cognitive performance and reported symptoms by subtracting each participant's pre-walk score from their post-walk score. Between-group comparisons were examined using univariate analysis of co-variance (ANCOVA), controlling for perceived safety and familiarity of the environment. Although perceived noise level differed between the two groups, less noise in a natural environment is considered to be an inherent part of the "naturalness" character of the environment and thus was not controlled for. Finally, to examine between-group differences in perceived restorativeness of the environment following their walk, similar univariate ANCOVAs were run, again controlling for perceived safety and familiarity.

CHAPTER IV:

RESULTS

Results from this study will be presented in four sections below. The first section provides participant characteristics. The second section includes participants' cognitive performance as measured by the maximum digits in DSB and latency and percent correct of incongruent trials in the SCWT (Research Question 1). The third section reports on self-reported symptoms (Research Question 2). The final section provides the results regarding the perceived restorativeness of the environments (Research Question 3).

Participant Characteristics

Information about study participants includes a) demographic characteristics and nature experience, b) ADHD information, including diagnosis, treatment, and family history, and c) perceptions of the environment where the walks occurred.

Demographics and Nature Experience

A majority of participants were female (60.0%) and ranged in age from 18 to 28, with a mean of 21 years (SD=2.33; table 2). Participants were distributed across classification (freshmen to graduate level students) as follows: 42.5% were underclassmen (i.e., freshmen and sophomores combined), and 42.5% were upperclassmen (i.e., juniors and seniors combined), and the remaining 15.0% identified themselves as graduate students. In terms of ethnicity, a vast majority of participants identified as White (95.0%), with only 2.5% Black and 2.5% Asian.

Table 2. Participant Demographic Information and Nature Experience

Demographics and Nature Experience	Overall (n=40)	Nature (n=20)	Urban (n=20)
Age (in years)	*M*=20.72 (SD=2.33)	*M*=20.10 (SD=1.71)	*M*=21.35 (SD=2.72)
		t = -1.74	
Gender			
Female	60.0%	55.0%	65.0%
Male	40.0%	45.0%	35.0%
		χ^2 = 0.42	
Race			
White	95.0%	95%	95.0%
Black	2.5%	0.0%	2.5%
Asian	2.5%	2.5%	0.0%
		χ^2 = 2.00	
Year in school			
Underclassmen[1]	42.5%	45.0%	40.0%
Upperclassmen[2]	42.5%	45.0%	40.0%
Graduate	15.0%	10.0%	20.0%
		χ^2 = 0.78	
How often spend time in nature			
About every day	5.0%	0.0%	10.0%
A few times per week	32.5%	25.0%	40.0%
A few times per month	57.5%	70.0%	45.0%
Never	5.0%	5.0%	5.0%
		χ^2 = 3.779	
Enjoy time in nature[3]	*M*=4.40 (SD=0.71)	*M*=4.30 (SD=0.80)	*M*=4.50 (SD=0.61)
		t = 0.89	

*$p<.05$; **$p<.001$; *** $p<.001$*
[1]Freshmen and Sophomores combined
[2]Juniors and Seniors combined
[3] 1 = strongly dislike to 5 = strongly enjoy

When asked about their use of outdoor green spaces (e.g., parks, forests, etc.), a majority of participants (57.5%) said they spend time in natural areas a few times per month, while about a third of participants (32.5%) reported using these areas a few times per week (Table 2). Only 5.0% used parks about every day and the remaining 5.0% reported never using parks. Overall, respondents reported high enjoyment of time spent in nature settings (*M*=4.40, SD=0.71). Also noteworthy is that no significant differences emerged between the two groups based on any of these demographic variables or participants' nature experience.

ADHD Information

As Table 3 shows, the age of ADHD diagnosis ranged from 6 to 25, with a mean age of 12.7 years (SD=5.10). Of the three subtypes, the most common among participants was the primarily inattentive type (42.5%) followed by combined type (40.0%) and primarily hyperactive/impulsive type (7.5%). The remaining 10.0% did not know their specific subtype. A majority of participants (73.0%) currently took medicine to treat ADHD, most of which took medication once daily (62.0%). Although this study could not directly measure the frequency of non-prescribed use of ADHD medication (because all participants were professionally diagnosed), it was evident that not all participants used the drugs as prescribed, with 17.0% reporting taking their medication at a frequency other than that which was prescribed. Finally, more than half of participants (55.0%) reported having an immediate family member also diagnosed with ADHD. Again, no significant differences emerged between groups regarding any of these items related to ADHD information or history.

Table 3. Participant ADHD Information

ADHD Measure	Overall (n=40)	Nature (n=20)	Urban (n=20)
Age of diagnosis	*M*=12.68 (SD=5.10)	*M*=12.60 (SD=4.19)	*M*=12.75 (SD=5.98)
		t = 0.09	
Family members diagnosed			
Yes	55.0%	55.0%	55.0%
No	37.5%	40.0%	35.0%
Don't know	7.5%	5.0%	10.0%
		χ^2 =0.40	
ADHD Subtype			
Inattentive	42.5%	45.0%	40.0%
Hyperactive/impulsive	7.5%	10.0%	5.0%
Combined	40.0%	25.0%	55.0%
Don't know	10.0%	20.0%	0.0%
		χ^2 = 6.64	
Currently taking medication			
Yes	72.5%	70.0%	75.0%
No	27.5%	30.0%	25.0%
		χ^2 =0.13	
Frequency taking medication			
Once daily	62.1%	64.3%	60.0%
Twice daily	13.8%	14.3%	13.3%
Weekdays only	3.4%	0%	6.7%
Only when needed	10.3%	14.3%	6.7%
Other	10.3%	7.1%	13.3%
		χ^2 = 1.63	
Is this prescribed frequency?			
Yes	82.8%	78.6%	86.7%
No	17.2%	21.4%	13.3%
		χ^2 = 0.33	
Take meds today?			
Yes	82.8%	85.7%	80%
No	17.2%	14.3%	20%
		χ^2 = 0.17	

*p<.05; **p<.001; *** p<.001

Perceptions of Environment

As seen in Table 4, respondents overall reported high perceptions of safety (*M*=4.05, SD=0.88), low levels of familiarity with the environment (*M*=1.43, SD=0.59), and moderate levels of noise. (*M*=3.00, SD=1.28). In addition, significant differences between the nature and urban groups emerged in each of these variables. Perceived safety was rated significantly higher for the nature group (*M*=4.40, SD=0.50) compared to the urban group (*M*=3.70, SD=1.03; t=-2.73, p=.016). However, participants were more

Table 4. Participant Perceptions of Environment

Perceptions of Environment	Overall (n=40)	Nature (n=20)	Urban (n=20)
Safety of environment[1]	4.05	4.40	3.70
		t = -2.73*	
Familiarity with environment[2]	1.43	1.05	1.80
		t = 5.12***	
Noise level in environment[3]	3.00	3.95	2.05
		t = -7.01***	
Other people (nature only)			
0	--	35.0%	--
1-5	--	65.0%	--
6-10	--	0.0%	--
More than 10	--	0.0%	--
Traffic (urban only)			
Very light	--	--	5.0%
Mostly light	--	--	5.0%
Neither	--	--	15.0%
Mostly heavy	--	--	55.0%
Very heavy	--	--	20.0%

*p<.05; **p<.001; *** p<.001
[1] 1 = Very dangerous to 5 = Very safe
[2] 1 = Not at all familiar to 3 = Very familiar
[3] 1 = Very loud to 5 = Very quiet

familiar with the urban area (*M*=1.80, SD=0.62) than the natural area (*M*=1.05, SD=0.22; t=5.12, p=.000). For perceived noise level, the state park trail was rated significantly quieter (*M*=3.95, SD=0.83) than the street sidewalk (*M*=2.05, SD=0.80; t=-7.01, p=.000).

Traffic was measured slightly different for each group, with the nature group reporting the number of other people they encountered during the walk and the urban group reporting the amount of traffic observed during the walk. Traffic on the nature path was rated as low, with all participants encountering five or less people (i.e., 65% encountered between one and five; 35% encountered no one). In contrast, traffic in the urban environment was rated as high, with 75% of the urban group reporting mostly heavy or very heavy traffic.

Cognitive Performance

Three measures of cognitive performance were used to examine participant's changes before and after the walk: maximum correct digits in the DSB, SCWT incongruent latency (i.e., reaction time), and SCWT incongruent percent correct (see Table 5).

Maximum Correct Digits in DSB

The nature group increased from *M*=7.15 (SD=1.14) pre-walk to *M*=7.40 (SD=1.19) post-walk for the maximum number correct in the DSB, although this was not a significant improvement (t=1.56, p=.135). Similarly, the urban group increased from *M*=6.40 (SD=1.31) pre-walk to *M*=6.75 (SD=1.29) post-walk, although again this was not a significant improvement (t=1.58, p=.130). When comparing the DSB difference scores, the improvements between the two groups were not significantly different (F=2.40, p=.716).

SCWT Incongruent Latency

Regarding the SCWT incongruent latency, the nature group score decreased from *M*=1386.01 (SD=419.06) pre-walk to *M*=1001.73 (SD=252.27) post-walk, a significant improvement in latency (i.e., reaction time; t=-5.60, p=.000). Likewise, the urban group score decreased from *M*=1117.46 (SD=265.58) pre-walk to *M*=925.47 (SD=220.43) post-walk, also a significant improvement (t=-4.51, p=.000). When comparing the latency difference scores, the improvements between the two groups were significantly different with the nature group improving more than the urban group in reaction time (F=1.85, p=.022).

SCWT Incongruent Percent Correct

The nature group increased from *M*=87.59 (SD=8.17) pre-walk to *M*=91.18 (SD=8.91) post-walk for the percent correct in the SCWT incongruent task, although this was not a significant improvement (t=1.70, p=.106). In contrast, the urban group increased from *M*=88.66 (SD=10.01) pre-walk to *M*=94.84 (SD=5.22) post-walk, which was a significant improvement (t=3.14, p=.005). However, comparing the difference scores shows that the improvements between the two groups were not significantly different (F=0.16, p=.376). In other words, the urban group did not improve more than the nature group.

ADHD Symptoms

All six survey items measuring self-reported ADHD symptoms were combined into a mean symptom score which displayed high internal reliability for both the pre-walk survey (α_{nature}=.853; α_{urban}=.892) and the post-walk survey (α_{nature}=.907; α_{urban}=.857). When examining changes, symptoms for neither the urban nor the nature group significantly changed from the pre- to post-walk survey. Specifically, the mean presence of symptoms in the nature group dropped from *M*=2.19 (SD=0.84) to *M*=1.90 (SD=0.97), but this change was not statistically significant (t=-1.26; p =.222). Likewise, for the urban group, mean reported symptoms dropped from *M*=2.33 (SD=0.93) to *M*=1.98 (SD=0.78), but it again was not a statistically significant decrease (t=-1.83; p =.083). The comparison of the difference scores for each group also indicated that the change in reported symptoms pre- to post-walk for the nature group was not significantly different than that of the urban group (F=0.20; p=.863).

Perceived Restorativeness

The mean score of the 26 PRS items displayed high internal reliability for both the nature (α=.904) and urban (α=.947) groups. When examining differences in the perceived restorativeness of each environment, participants in the nature walk group (*M*=3.85, SD=0.52) rated the nature environment as significantly more restorative than the participants in the urban walk group rated the urban environment (*M*=2.78, SD=0.75; F=20.22, p=.000).

Table 5. Results of Cognitive Tests, Symptoms, and Perceived Restorativeness

	Nature (n=20)			**Urban (n=20)**			**Between Group Comparison**[1]		
	Pre-walk *M* (SD)	**Post-walk *M* (SD)**	**t-value**	**Pre-walk *M* (SD)**	**Post-walk *M* (SD)**	**t-value**	***ΔM* Nature**	***ΔM* Urban**	**F-value**
Cognitive Measure									
DSB[2]	7.15 (1.14)	7.40 (1.19)	1.56	6.40 (1.31)	6.75 (1.29)	1.58	0.25	0.35	2.40
SCWT incongruent latency[3]	1386.01 (419.06)	1001.73 (252.27)	-5.60***	1117.46 (265.58)	925.47 (220.43)	-4.51***	-384.29	-191.99	1.85*
SCWT incongruent percent correct[3]	87.59 (8.17)	91.18 (8.91)	1.70	88.66 (10.01)	94.84 (5.22)	3.14*	3.59	6.18	0.16
Reported Symptoms[4]	2.19 (0.84)	1.90 (0.97)	-1.26	2.33 (0.93)	1.98 (0.78)	-1.83	-0.29	-0.34	0.20
Perceived Restorativeness[5]	--	3.85 (0.52)	--	--	2.78 (0.75)	--	--	--	20.22***

*p<.05; **p<.001; *** p<.001
[1] Controlling for perceived safety and familiarity
[2] Digit Span Backwards
[3] Stroop Color Word Test
[4] Scale of 6 ADHD symptom items (α=.853-.907)
[5] Scale of 26 Perceived Restorativeness items (α=.904-.947)

CHAPTER V:

DISCUSSION

This study builds upon previous research (e.g., Berman et al., 2008; Felsten, 2009; Faber Taylor & Kuo, 2009) examining the cognitive benefits of nature exposure. Results yielded mixed support for the study hypotheses, suggesting that walks in nature can be restorative for university students with ADHD, although additional research is also recommended.

Both the nature and urban groups improved in their reaction time (i.e., latency of incongruent trials in SCWT) after the walk. This is not surprising given that there may be a learning effect of taking the cognitive test (Berto, 2005), and that simply walking in general may help improve cognitive abilities (Voss et al., 2010). However, the finding that the nature group resulted in a significantly greater improvement beyond the urban group indicates that nature has the ability to restore directed attention of young adults with existing attentional deficits. This supports previous research that also found positive attentional aftereffects following nature exposure in studies with youth (e.g., Faber Taylor & Kuo, 2009).

However, in contrast to expectations, walking in nature did not significantly increase the number of correct associations in the cognitive tests (i.e., maximum digits in DSB; percent of correct incongruent trials in SCWT). Although scores in both of these cognitive measures improved for the nature and urban groups, they were not significant changes except for the percent of correct incongruent trials in SCWT for the urban group. Once again, while some within-group improvements are expected (Berto, 2005; Voss et al., 2010), findings did not demonstrate the hypothesized greater improvement in the nature group compared to the urban group. These findings are inconsistent with previous research that found significant improvements in youth with ADHD using the DSB (e.g., Faber Taylor & Kuo, 2009) and non-ADHD youth using the SCWT (e.g., Faber Taylor, Kuo, & Sullivan, 2002), as well as the SCWT latency findings in this study. However, similar DSB findings are reflected in a previous study by Tennessen & Cimprich (1995), in which participants exposed to natural versus urban environments also did not demonstrate significant differences in DSB scores

An explanation behind only one of three cognitive measurements showing significant improvements in the nature group may lie in the difficulty of using repeated trials measurement tools to capture cognitive abilities at different times with this population. For example, Faber Taylor and Kuo (2009, p. 404) explain that “lack of power in a repeated measures design with an ADHD population is not surprising, as one of the hallmarks of ADHD is high variability in performance, particularly on multi-trial tasks.” Therefore, while cognitive tests are useful measures, this study did not rely completely on repeated measures of established cognitive tasks, also taking into account reported prevalence of symptoms and perceived restorativeness.

Although self-reported ADHD symptoms decreased after the walk for both the nature and urban group, this decrease was not significant for either one. Further, in contrast to expectations, there was not a significantly greater decrease in self-reported symptoms for the nature group. This finding contrasts some previous research that did find improvement in symptoms following exposure to natural environments (i.e., Faber Taylor et al., 2001; Kuo & Faber Taylor, 2004). However, those studies relied on parental reports of children's symptoms, and only examined inattention and not the hyperactivity/impulsive symptoms this current study also included. The non-significant changes in self-reported symptoms in this study may be due to a lack of statistical power given the small sample size of 20 individuals in each condition environment. In addition, the use of self-reported ADHD symptoms may be problematic, as previous studies utilizing self-report measures have called for further future research into the validity of self-reported prevalence of ADHD in university students (e.g., DuPaul et al., 2001).

Finally, results showed that the nature walk group perceived their environment to be significantly more restorative than the urban walk group. These findings correspond with previous studies testing Kaplan's Attention Restoration Theory and indicate the restorative benefits of nature exposure (e.g., Faber Taylor & Kuo, 2009; Berman et al., 2008; Berto, 2005). This finding suggests that natural environments are perceived to be more restorative than urban environments by a previously unstudied population (i.e., college students diagnosed with ADHD).

The improvement in the nature group's reaction time, together with greater perceived restorativeness, suggests that although the participants may not perceive the changes in their ADHD symptoms, those walking in nature are demonstrating improved directed attention after the walk. Although self-reported symptoms were not a significant source of improvement in this study, this methodological diversity embodies the shift that must occur if researchers are to successfully study this population in the future.

Limitations and Future Research

The sample size of the current study represents both a relative strength and a weakness when compared to similar studies. Although the sample size of this study is larger than previous studies involving ADHD populations, which involved no more than 17 participants (Faber Taylor & Kuo, 2009), the final sample size of 40 still limits the power to detect significant differences. Indeed, many of the findings were trending in the expected direction, and a larger sample may have revealed significant findings. In addition, the small sample also limited the ability to control for additional factors (due both lack of variation and power to include additional variables) such as gender, age, ADHD subtype, medication use, and ethnicity. As such, future research with larger sample sizes is recommended in order to control for these and other outside factors.

Furthermore, future studies could also make comparisons between the current study's population (i.e., college students with ADHD) and other groups of young adults (e.g., college students without ADHD, those diagnosed with ADHD but not attending college). For example, it would be useful to examine young adults attending college and make comparisons between those with and without diagnosed ADHD; such comparisons could examine if nature exposure has restorative benefits to all college students that commonly experience directed attention fatigue, or if it is particularly beneficial to those individuals with existing attentional deficits. Future research could also compare young adults diagnosed with ADHD attending college to similarly-aged peers diagnosed with ADHD but not attending college. As a small proportion of individuals diagnosed with ADHD attend college, and even fewer in 4-year institutions (Wagner et al., 2005) these university students may have developed coping skills to manage their symptoms and possibly possess a heightened cognitive capacity as well. As such, understanding the impact of nature exposure on both groups of young adults with ADHD would be informative.

Likewise, making comparisons between males and females diagnosed with ADHD in future research would be advantageous to examine potential differences in exposure to nature. While the current study collected participant gender, we were not able include gender comparisons due to our small sample. This may be particularly interesting in future research given the supposedly significant, yet largely undiagnosed population of females with ADHD (Crawford, 2003). Specifically, the national ratio of childhood diagnosis of ADHD for boys to girls is approximately 4:1, meaning that it is considerably more likely for boys to be diagnosed as it is for girls (APA, 2000). However, females with ADHD are much more likely to be diagnosed with the "invisible" primarily inattentive subtype, as opposed to the more visible hyperactive-impulsive or combined subtype, much more commonly seen in males. Females are therefore less likely to exhibit functional impairments like learning disabilities, major depression, and disruptive behavior disorders, which often lead to clinical referrals for ADHD (Biederman et al., 2002). Because these more overt warning signs are less common in females, particularly young girls, this may create a referral bias in which females are systematically under-diagnosed with ADHD (Biederman, 2002; Gaub & Carlson, 1997). Because this study's female participation rate (60.0%) was much higher than the childhood diagnosis ratio, perhaps creating a follow-up study that looks at both female university students diagnosed with ADHD and female university students at large could be beneficial. Specifically, it could provide an opportunity to compare the two groups' attentional responses to nature therapy, shed some light on this emerging research area, and provide more targeted solutions for achieving attention restoration for specific population segments.

A second limitation of the current study is the use of self-report measures of symptom prevalence as part of the supplementary questionnaire as opposed to observational or directly measured. The diagnosis of ADHD is innately challenging, in that it is largely based on self-report measures, which can present its own set of challenges to physicians charged with diagnosing and treating it (Adler, Kessler, & Spencer, 2003). A more sophisticated method of capturing data on attention would be to observe real-time brain activity during a walk in different environments using mobile EEG technology. This technology was used by Aspinall and colleagues in a recent study (2013), wherein participants wore the device and carried a backpack containing a receiver laptop and GPS unit. Although this technology presents exciting new possibilities for future research, there are major financial costs associated with this type of measurement tool and was not feasible for the current study. Therefore, self-reported data related to ADHD symptom prevalence remains an important tool, yet refining existing measurements is recommended (DuPaul et al., 2001).

An additional limitation of the present study pertains to the location of the pre- and post-intervention measures (i.e., cognitive tests and questionnaires). Although conducting these measures in the same setting for all participants would reduce the impact of the setting on the measures, this study followed the protocol of previous research in this field (e.g., van der Berg & van der Berg, 2010) and administered all pre- and post-walk measures on-site. In particular, administering these measures at one central location for both groups would have required a significant time delay between measures, both pre- and post-walk, and the intervention itself. This travel time and experience would have been highly uncontrollable and would have likely diminished the impact of the walk.

<u>Conclusions</u>

ADHD is a prevalent, diagnosable behavioral disorder shown to persist into young adulthood, although it is harder to detect (Kessler et al., 2005). This has led multitudes of college students to ignore their diagnosis or illegally self-medicate to manage their recurring symptoms (Aikins, 2011), which most commonly manifest themselves in the form of inattention. Treating ADHD with medication is commonplace in childhood, although it is highly stigmatized beyond adolescence and increasingly inaccessible (Aikins, 2011). College students diagnosed with ADHD struggle with some of the same obstacles they experienced as children, coupled with heightened expectations and responsibilities of higher education. As this segment of the population is growing increasingly visible in the research community (e.g., DuPaul et al., 2009; Frazier et al., 2007; Weyandt & DuPaul, 2006), so too is the need for alternative means of treating the disorder without relying completely on medication.

Because regularly spending time in natural settings has been proposed as one alternative treatment for ADHD by improving cognitive functioning, this study examined nature's restorative potential for the understudied population of college students with ADHD. Findings from this study provide further evidence of the cognitive benefits of nature exposure and its restorative potential, although additional research is recommended. Particularly for those affected by ADHD, better understanding of potential alternative mechanisms to cope with symptoms could translate into enhanced academic and professional performance while lessening the dependence on pharmaceutical drugs to manage ADHD symptoms. At the same time, these findings advocate for the importance of using existing natural areas as well as incorporating natural "green" spaces into future development in an increasingly urbanized world.

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APPENDIX A. PRE-WALK ADHD QUESTIONNAIRE

First, please tell us about your ADHD history.

1. At what age were you diagnosed with ADHD?

_______________ years old when diagnosed

2. Has anyone else in your immediate family been diagnosed with ADHD (e.g., siblings, parents)?

□ Yes
□ No
□ Don't know

3. Do you currently take medication to treat your ADHD symptoms? *(If no, skip to Question 4)*

□ Yes (*please answer questions 3a, 3b, and 3c*)
□ No (*skip to question 4*)
□ Prefer not to say (*skip to question 4*)

If yes…

3a. How often do you take your medicine?
□ Once daily
□ Twice daily
□ Weekdays only
□ Only when needed
□ Other (*please specify*) _________________

3b. Is this the prescribed frequency of use?
□ Yes
□ No
□ Not sure

3c. Did you take your medication today?
□ Yes
□ No
□ Prefer not to say

4. Which ADHD subtype best describes you? *(Please select only one)*
□ Primarily inattentive type
□ Primarily hyperactive/impulsive type
□ Combined type
□ Don't know

(Please turn over)

Next, we would like to know about the current ADHD symptoms you are experiencing.

5. Thinking about how you feel <u>right now</u> before the walk, to what degree do you believe the following characteristics describe you?

	Not at all	Some-what	For the most part	Very much	Comp-letely
a. I am having trouble paying close attention to details (i.e., having to read instructions multiple times)	1	2	3	4	5
b. I am having a difficult time sustaining my attention in this survey task (i.e., needing a mental break while reading)	1	2	3	4	5
c. I feel easily distracted by things going on around me (e.g., car noises, wildlife, other people)	1	2	3	4	5
d. I am finding it hard to sit still (e.g., fidgeting with my hands or feet while seated)	1	2	3	4	5
e. I am feeling physically restless (e.g., difficulty remaining seated through entire survey and concentration test)	1	2	3	4	5
f. I feel impatient (e.g., when I was waiting to start my walk or survey)	1	2	3	4	5

Now, please tell us a little bit about the time you spend outdoors in nature.

6. To what degree do you enjoy spending time outdoors in natural settings (e.g., parks, forests, etc.)?
□ Strongly dislike □ Dislike □ Neutral □ Enjoy □ Strongly enjoy

7. How often do you spend time outdoors in natural settings (e.g., parks, forests, etc.)?
□ Never □ A few times per month □ A few times per week □ About every day

Finally, please tell us a little bit about yourself.

8. What year were you born? 19______

9. Your current year in school? □ Freshman □ Sophomore □ Junior □ Senior □ Other

10. What is your gender? □ Male □ Female □ Prefer not to say

11. Are you of Hispanic or Latino origin? □ Yes □ No

12. Which race/ethnicity best describes you? *(check all that apply)*
□ American Indian or Alaska Native
□ Asian
□ Black
□ Native Hawaiian or Other Pacific Islander
□ White
□ Other (please specify) ________________________

Thank you! Please return this form to Laura, and she will direct you for your walk.

APPENDIX B. POST-WALK ADHD SURVEY

Please tell us again about the current ADHD symptoms you are experiencing.

1. **Thinking about how you feel right now after the walk you just took, to what degree do you believe the following characteristics describe you?**

	Not at all	Some-what	For the most part	Very much	Completely
a. I am having trouble paying close attention to details (i.e., having to read instructions multiple times)	1	2	3	4	5
b. I am having a difficult time sustaining my attention in this survey task (i.e., needing a mental break while reading)	1	2	3	4	5
c. I feel easily distracted by things going on around me (e.g., car noises, wildlife, other people)	1	2	3	4	5
d. I am finding it hard to sit still (e.g., fidgeting with my hands or feet while seated)	1	2	3	4	5
e. I am feeling physically restless (e.g., difficulty remaining seated through entire survey and concentration test)	1	2	3	4	5
f. I feel impatient (e.g., when I was waiting to start my walk or survey)	1	2	3	4	5

Next, please tell us about your impressions of the environment you went for a walk in.

2. How safe would you rate this environment?

□ Very dangerous □ Mostly dangerous □ Neither □ Mostly safe □ Very safe

3. How would you rate the noise level in this environment? (i.e., cars, other people, etc.)

□ Very loud □ Mostly loud □ Neither □ Mostly quiet □ Very quiet

4. Before today, how familiar were you with the area you walked in?

□ Not at all familiar □ Somewhat familiar □ Very familiar

(Urban only) **5. How would you rate the traffic flow of this area during your walk?**

□ Very light □ Mostly light □ Neither □ Mostly heavy □ Very heavy

(Nature only) **5. About how many people did you encounter during your walk?**

□ 0 □ 1-5 □ 6-10 □ More than 10

(Please turn over)

Finally, we have some questions for you about your surroundings during the walk

6. Based on the walk you just completed, to what extent do you agree or disagree with the following statements?

	Strongly Disagree	Disagree	Neither	Agree	Strongly Agree
a. It is easy to find my way around here.	1	2	3	4	5
b. My attention is drawn to many interesting things here.	1	2	3	4	5
c. There is nothing worth looking at here.	1	2	3	4	5
d. Being here helps me to relax my focus on getting things done.	1	2	3	4	5
e. This setting is fascinating.	1	2	3	4	5
f. Spending time here gives me a break from my day-to-day routine.	1	2	3	4	5
g. I want to spend more time looking at the surroundings.	1	2	3	4	5
h. I can do things I like here.	1	2	3	4	5
i. Coming here helps me to get relief from unwanted demands on my attention.	1	2	3	4	5
j. There is too much going on in this setting.	1	2	3	4	5
k. It is a confusing place.	1	2	3	4	5
l. It is a place to get away from it all.	1	2	3	4	5
m. Being here is an escape experience.	1	2	3	4	5
n. It is easy to see how things are organized in this setting.	1	2	3	4	5
o. I can find ways to enjoy myself here.	1	2	3	4	5
p. I could easily form a mental map of this place.	1	2	3	4	5
q. This place is boring.	1	2	3	4	5
r. Being here suits my personality.	1	2	3	4	5
s. There is much to explore and discover here.	1	2	3	4	5
t. This place has fascinating qualities.	1	2	3	4	5
u. There are landmarks to help me get around.	1	2	3	4	5
v. I have a sense that I belong here.	1	2	3	4	5
w. It is chaotic here.	1	2	3	4	5
x. There is a great deal of distraction here.	1	2	3	4	5
y. I want to get to know this place better.	1	2	3	4	5
z. I have a sense of oneness (i.e., connectedness) with this setting.	1	2	3	4	5

***Thank you for your time! Your responses are appreciated. Please return this form to Laura to receive your gift card*.**